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ABSTRACT

This report describes Palenque, an interactive, multimedia, optical disc research prototype developed for home use by 8- to 14-year-old children and their families. The report begins by providing an overview of the project, which is followed by a discussion of the target audience and context for use of the videodisc. A discussion of learning philosophy covers the roots of traditional instructional design, the substitution of less traditional roots for the design of elements of the Palenque discovery learning model how the design fosters incidental learning, and the creation of a flexible environment that allows for extended sessions and repeatability. The nature of the medium is then addressed--the unique features of the optical disc medium, inspiration from other projects, and features of the DVI (Digital Video Interactive) Development System. Design elements of materials that are incorporated in Palenque are described, including linear television narratives, interactive narratives, simulations, interactive games, multimedia databases, and interactive books. The report concludes with discussions of the concurrent process of design and development as research and the implications of future design efforts. (19 references) (MES)

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THE PALENQUE OPTICAL DISC PROTOTYPE: THE DESIGN OF MULTIMEDIA EXPERIENCES FOR EDUCATION AND ENTERTAINMENT IN A NONTRADITIONAL LEARNING CONTEXT*

Kathleen S. Wilson

Introduction

Palenque is an interactive, multimedia, optical disc research prototype which has been developed for home use by 8- to 14-year-old children and their families. Palenque incorporates themes, locations, and several characters from Bank Street's "Second Voyage of the Mimi" television show, which introduces middle-school children to the science of archeology and the culture of the ancient Maya in Mexico's Yucatan peninsula. The "Mimi" materials include a television show, print materials, and four pieces of computer software designed for use by teachers and students in fourth to sixth grade classrooms. A major goal of these materials is to motivate children's interest in science as a "real-world" activity, and to make various scientific concepts understandable to a wide range of children.

We chose the site of Palenque for our interactive prototype both because it is one of the ancient Maya sites protrayed in the "Mimi" TV show, and because it is a spectacular location with many reconstructed Maya temples, surrounded by a lush tropical rainforest near the foothills of the Guatemalan highlands. With our interactive prototype, children can use a joystick to take a self-directed, simulated "walk" around the ancient Maya site at Palenque, either through the

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The Palenque Project was funded by the David Sarnoff Research Center, Princeton, NJ (formerly GE/RCA Labs).

Major project contributors: John Borden, Samuel Gibbon, Donna Goldstein, Joana Hattery, Jenny Howland, Richard Hendrick, Robert Mohl, Marcia Perskie, Richard Ruopp, Jeffrey Strange, George Stuart, William Tally, and Kathleen Wilson for Bank Street College of Education; Thomas Craver, Holly Faubel, Jesse Kapili, Richard Levine, Sandra Morris, David Ripley, and Paula Zimmerman for the David Sarnoff Research Center.

rainforest or through a simulated Palenque "Museum" database. We have attempted to design an experience for children that allows them to browse freely, make choices about what to see, when and where, and discover things along the way as they explore (Wilson, 1987).

The Palenque optical disc prototype varies in several ways from interactive videodiscs designed with more traditional instructional design principles in mind. Since the project is a research and development effort rather than a product development effort, we have been able to experiment with the nature of the design as well as with the design process itself. In this experimental vein, we have attempted to incorporate many interactive learning formats into the Palenque disc. Although it is not an easy task to define Palenque, one thing is clear: It is not a step-by-step instructional sequence. At the core, it is a database that includes information stored in a variety of formats (graphics, text, sounds, narration, slides, motion video), which has been organized to foster browsing rather than precise searching. The browsing is structured implicitly in two ways: (a) spatially, by a virtual travel component where the user "walks," for example, to a temple to find out information about that temple; and (b) topically, by a "Museum" component with its four theme rooms. Palenque also has elements of simulations, interactive games and books, and linear television narratives, all accessible via an intuitively simple interface. These elements have been woven together in an attempt to create an informative and fun experience for children and their families. As outlined below, the unique demands of our goals, target audience, learning philosophy, choice of medium, and formative research tradition have all influenced the nature of our design and development decisions.

Palenque Project Overview

The Palenque project has been a collaborative effort between Bank Street College of Education in New York City and the David Sarnoff Research Center (formerly GE/RCA Labs) in Princeton, New Jersey. Bank Street College has been principally responsible for design, production, and research, while the David Sarnoff Research Center has been principally responsible for technical implementation. The project has involved a number of research directions, both educational and technical, since its inception in 1985. We have been able to experiment with pedagogy and interface design, an issue that is at the heart of much of the research and educational product development at Bank Street College. Thus, for example, we have experimented with creating an interactive, multimedia information environment for children and their families that piques curiosity and fosters self-guided exploration, information seeking, and decision making.

In the areas of production, programming, and technical research, we have used the Palenque prototype as a vehicle for designing and developing an experimental, highly interactive, optical disc prototype. Our collaboration with the David Sarnoff Research Center, the funder of the Palenque project, has allowed us to experiment with state-of-the-art optical disc and computing technology. Palenque was designed, in part, as one of several demonstration applications for DVI* (Digital Video Interactive) technology. DVI has been under development for several years at the David Sarnoff Research Center, and was introduced at Microsoft's CD-ROM conference in Seattle on March 4, 1987. It is an integrated video and graphics technology that provides full-motion, full-screen video, 3-dimensional motion graphics, and high-quality audio capabilities from a single CD-ROM disc. We have attempted to incorporate into the design of Palenque as many of the advanced features of this technology as the limitations of time, money, and human resources available to us will allow.

Target Audience and Context for Use

Children and Their Families in the Home Context

Many of the optical videodiscs currently in use have been designed for instructional purposes in corporate and military settings or for tutorial purposes in classrooms. The design of Palenque varies in several ways from these discs, in part because it has been created for use in a different context. Rather than having been designed for use in offices or adult training centers, or for use in classrooms as have the rest of the "Mimi" materials, Palenque has been designed for home use by families with children in the 8- to 14-year age range. The age range for the children in our target audience was determined by the target audience for Bank Street's "Second Voyage of the Mimi" materials.

An Accessible Interface

With a nonschool learning environment such as the home in mind, we have experimented with the creation of an interface and interactive experience that is easy to learn to use, appealing, and comprehensible to a wide variety of users. Toward this end, we have used a simple interface device (a Gravis joystick) and accessible interface conventions, such as dynamic, pictographic icons, multiple windows for easy access to information, and the "real-life" metaphors described below. We have attempted to balance entertainment and educational values, so that the experience of using Palenque can be informa-

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tive and, at the same time, self-motivating and fun for various family members. Thus, in order to add to the appeal of Palenque, we have incorporated such things as ambient audio sound effects, bright colors, high-resolution graphics, highly realistic photographs and motion video, human dialogue with touches of humor, and a variety of special video effects.

Metaphors from "Real Life"

In the early stages of our design process, we explored the kinds of things families do together that are fun and, at the same time, potential learning experiences. What came to mind were such activities as visits to museums, zoos, and libraries, trips to distant places, reading books or playing games together, and watching educational videotapes or broadcast television shows. We incorporated aspects of these typical family activities into our design as vehicles for facilitating learning about the ancient Maya and the site at Palenque. Through the use of these metaphors, our information environment and user interface have merged.

Knowing how to explore a space in the real world seems to make it easier to explore a simulated space (Hooper, 1980). For example, with the Palenque prototype, knowing that a camera is used to take pictures and that an album is a place to store pictures and text allows one more easily to collect pictures found while exploring (with our simulated camera) and save them (in our simulated album). It seems that recognition of metaphors such as these and previous knowledge of how to proceed with them in the real world makes the Palenque experience more accessible to a range of users.

Learning Philosophy

The Roots of Traditional Instructional Design

Many instructional, interactive courses are rooted in the task-analysis approach of psychologists (Gagne, 1975; Rowntree, 1982). In military and corporate settings, interactive videodiscs are often designed to teach adults specific procedural tasks, such as how to repair, install, or use a piece of equipment. These interactive videodisc courses offer great advantages to large companies in terms of standardized, efficient, and effective training. In many such courses, the student proceeds through a pre-test, a prescribed sequence of small, incremental steps, reinforcement, or quizzes on the mastery of chunks of steps, and a final post-test upon completion of the course.

Courses such as these are explicitly structured by course designers to ensure that users will proceed through all the necessary steps in

the instructional sequence. Some of the design assumptions are:

- Since motivation is often not an issue, the extra cost to create colorful graphics or touches of humor is rarely justified.
- There is an optimal path through the course material; thus, learners have few choices in terms of the sequence or style of progress through a course.
- Post-tests are important because they adequately measure learning.
- Reducing the time spent on course completion is important because this saves the company money by reducing the time spent away from the job.

Elements of The Discovery Learning Model in Palenque

While the instructional design format described above is quite effective for many purposes and in many settings, several of the assumptions upon which it is based did not seem suitable to the demands of our home context and child-centered audience. We thus turned to pedagogical roots other than those proposed by the task analysts. Our design philosophy is more akin to the discovery learning ideas of Bruner (1977, 1982, 1985), the "spontaneous learning" situations described by Vygotsky (1962), and the ideas of Piaget regarding the natural ways that thought develops (Piaget (1973) than to the programmed instruction ideas of, for example, Skinner (1954).

Fostering Incidental Learning

The learning in Palenque tends to be incidental in nature as one discovers new information and new connections between pieces of information while navigating through the highly visual information spaces of the database. Children seem to pick up facts along the way while exploring, as well as an implicit understanding of the structure of the information organization itself. For example, due to the location of information about "kinkajous" in our museum database and the conceptual path that one must navigate to discover this information, one learns that a kinkajou is a mammal that lives in the rainforest canopy "along the way" to getting from rainforest to kinkajou.

This browsing path toward kinkajous begins in the Museum Rainforest Room with a colorful graphic image of a rainforest divided into four layers: water, floor, understory, and canopy. Within each layer can be seen representative icons of rainforest mammals, birds, insects, reptiles, and plants. If the rainforest canopy layer mammal icon is selected, the child is presented with a selection of three images of

canopy layer mammals: spider monkeys, kinkajous, and howler monkeys. If the child selects the kinkajou image here, text and photographic information about kinkajous will appear. By following a route such as this, incidental learning is encouraged because the information is implicitly structured into categories and themes that are linked visually and conceptually.

Extended Sessions and Repeatability

Rather than presenting explicitly structured instructional sequences, we have used the optical disc medium to create a motivating information environment that can be explored with the freedom to browse and discover things at will (albeit with some guidance). Our goal has been to foster exploration, discovery, and information-seeking by creating an environment that compels children to probe at length and to want to return on repeated occasions. Rather than trying to make interactions as time efficient as possible, as in most corporate training courses, one of our goals has been to establish an environment that is rich enough to encourage extended sessions and repeat visits. The richness of Palenque is in both the number of interactive options and the variety of information formats available to the user.

The Nature of the Medium

Unique Features of the Optical Disc Medium

In the early stages of the design of Palenque, we considered the unique features of the interactive optical disc medium and how best to maximize them for our design purposes. We began with the notion that one of the best uses of optical discs is for the storage of large amounts of information in a variety of formats, including high realism and high-resolution video and audio information, whether it be analog information stored on 12-inch videodiscs or digital information compressed and stored on CD-ROM discs. With the quick-search, random-access capabilities of the laser disc medium and the interactive branching capabilities of computer control, rich multimedia information can be easily searched and sorted in any number of ways by individual users. In addition, the computer component of the disc system allows the designer to create updatable graphics overlays--such as text, icons, highlights, wipes, and dissolves--which greatly increase the number of ways that still and motion video and sound stored on the disc can be used.

Inspiration from MIT

We also looked to models proposed by other relevant projects that might inform our evolving design. Several projects conducted by the

Architecture Machine Group (now part of the Arts and the Media Technology Group) at MIT, which concentrated on issues of user interface, seemed to be the most relevant for our purposes (Bolt, 1984; Lippman, 1984; Negroponte, 1970). The Spatial Data Management system (Bolt, 1979) allows users to access information by "going" to where it is stored (e.g., on an image of a desk top) rather than by searching for it by name. The Aspen Movie Map (videodisc-based) system (Mohl, 1982) allows users to take a simulated, first-person point of view "drive" around the town of Aspen, consult various scales and representations of Aspen maps, and "visit" selected buildings for cultural information about the town. It involves a similar notion to that of the Spatial Data Management system in that users "drive" to locations in order to get information about them. The Movie Manual system (Backer, 1985) is an interactive, videodisc-based car repair manual that provides users with text information, slides, and narrated movies of various car repair procedures and tools. In the Movie Map, information for the most part is stored and accessed via a conceptual rather than a spatial framework as in SDMS or the Aspen Movie Map. Access to information in all of these projects is possible through highly visual menus, such as maps, diagrams, and pictures, as well as through text.

Inspiration from Previous Videodisc Research and Prototyping

Previous videodisc prototyping and research conducted at Bank Street College (Wilson, 1985, 1986) was relevant to our design process. This work showed us a number of things: that high-quality motion video of real-life characters interacting or whales breaching, for example, and high-quality, realistic sound, especially music and people singing, were particularly appealing to children; that control over these images and sounds was both appealing and motivating to children; and that using a videodisc as a multimedia database to be explored via highly visual-metaphorical menus could be understood by and was fun for children.

The DVI Development System

One of the design goals of the Palenque project was to incorporate the results of our previous research with children using videodiscs with the strengths and unique capabilities of the David Sarnoff Research Center's evolving DVI technology. Since the DVI hardware development paralleled our Palenque software development, we used a development system that was configured to resemble the final DVI system in as many ways as possible. This customized system included a Sony LDP 2000/2 laser videodisc player, an IBM PC-AT computer with extended memory, an AT&T Targa Graphics Board, a custom digital audio board, an IBM monitor, a 20" RCA stereo color TV set,

and a Gravis joystick. Custom software tools were also developed to meet the unique demands of an application designed for DVI technology.

This videodisc system allowed us to store 54,000 frames of still images on the disc, of which approximately 18,000 are full-screen motion video segments (played at 30 frames per second); 23,000 are sequenced (first-person point of view) stills that comprise the virtual travel routes and branches; 2,000 are still photographs of buildings, rainforest animals, maps, historical drawings and photographs, artifacts, etc.; and 11,000 are variably sized screen-motion video segments. Two 30-minute audio tracks of narration, music, and sound effects are also fully used. Our custom sound board allowed us to play, among other things, continuous ambient rainforest sounds while users stepped through the still sequences comprising virtual travel.

Because one of the revolutionary aspects of DVI technology is the capability of storing digitized full-screen, full-motion video (30 frames per second) on a CD-ROM disc, one of our priorities was the effective use of full-motion video in our application. It is partly for this reason that we have we used full-motion video information in our Palenque Museum, such as segments of howler monkeys playing in the rainforest canopy and aerial passes over the Palenque site, which complement the slides, text, graphics, audio narration, and sound effects also found in the Museum. In addition, we have motion video segments of characters introducing various system options and features, providing travel guidance and companionship, and presenting expert archeological information about Palenque.

Other features of the DVI system that we attempted to incorporate in the Palenque prototype are the capability of continuous audio and video information with no noticeable search time; multiple, movable video windows; user control of video information (e.g., pans and tilts); and user control of multiple-channel, high-quality audio information. These features are reflected in such aspects of Palenque as the seamless virtual travel sequences and branches; the camera tool, which allows children to take a picture by digitizing and reducing a selected frame from the disc; the album, which allows children to place digitized and reduced camera images side by side for comparisons on opposite album pages; a "magic flashlight," which allows children to dissolve between digitized historical photographs of Palenque and present-day photographs of the same locations; a digitized and unwrapped fish-eye pan and tilt, which allows children to see a 360° panoramic view from various locations on the Palenque site; and a rainforest symphony game, which allows children to create their own multi-track symphony of sounds selected from pictures of objects and animals that create those sounds.

Palenque Prototype Design Description

As stated in the opening section of this paper, Palenque is not easy to describe due largely to the experimental nature of the prototype. We have attempted to incorporate into our design elements of several different media formats in order to explore their appeal and effectiveness for children. For example, we have included elements of linear television narratives, interactive narratives, simulations, interactive games, multimedia databases, and interactive books. These elements have been woven together in an attempt to create a cohesive experience for child users as they browse through the rich information environment of Palenque.

Elements of Linear Television Narratives

Our Palenque prototype complements Bank Street's "Voyage of the Mimi" materials by providing experiences for children that are different from those provided by the other aspects of the "Mimi" package (TV show, computer software, and print materials), and by integrating video and computing technologies into one system. Palenque incorporates the "Mimi" themes in that the user's experience is based on a first-person point of view exploration of the ancient Maya site, Palenque, which is also the scene of one of the TV segments, and on the perusal of a multimedia Palenque Museum database. It incorporates the "Mimi" characters, making them available on the Palenque disc from time to time to introduce sections of the prototype, provide travel tips and guidance, and offer expert archeological information.

Thus, the disc has some of the compelling narrative elements of the television show, such as the use of the Maya theme, Palenque location, and "Mimi" characters, without the linear narrative progression of the television dramas or documentaries. Linear, quasi-narrative video is incorporated into Palenque in the form of overviews, character guidance, and expert information. However, these segments are never more than two minutes in length and are intended more to relay information than to tell a story.

Elements of Interactive Narratives

Palenque complements the "Mimi" TV segments because it allows children to take their own simulated visit to a Maya site and museum by using a joystick to control movement along travel routes and through conceptual museum spaces. In a sense, by their navigational choices, children create their own Palenque story as they explore the various modes and information spaces available to them. With Palenque, children can discover and probe places and concepts that are of interest to them. The prototype presents them with a rich visual and

auditory environment and a host of options all along the way, such as the option to see a panoramic view or to zoom in visually to selected spots on the site for further text, video, and narrative information. The route through the information is completely determined by the individual user. Any choice is acceptable and steps can be easily retraced or undone. In this way, Palenque is nonjudgmental and there really are no "wrong" choices that children can make.

Elements of Simulations and Interactive Games

The exploratory nature of the Palenque prototype disc varies from the more structured "Mimi" software materials, which are designed for classroom use to help children experiment with specific facts and understandings about the Maya, such as their systems of mathematics, astronomy, and architecture. In keeping with the demands of the classroom setting and the intended classroom learning goals, the "Mimi" software materials are more explicitly structured than the Palenque prototype. Some are structured as tutorial sequences, some as computerized tools, and some as directed activities and games.

Although Palenque has some of these elements, they do not provide the overall structure of the prototype. For example, the virtual travel experience of "walking around" the site is similar in some ways to an adventure game or simulation. In this Explore Mode, children can make their own decisions about where to wander in the environment, what things to investigate, and when to record them as "photos" in their album. Palenque provides them with a controllable world to explore. Several tools are available to help them in these explorations, including a camera, a tape recorder, a compass, a magic flashlight, and a dynamic you-are-here map. Children ask questions, in a sense, by making choices about where to go, what to see or hear, and what tools to use while browsing through the Palenque environment.

The Game Mode of Palenque has been created to provide a loose structure, in the form of a scavenger hunt game, for children who prefer some guidance for navigating through the Palenque information environment. In the Museum Mode, several game-like activities have been included in the theme rooms in an attempt to make the experience similar to a hands-on children's museum. These include games that allow children to put fragmented glyph panels together and to create their own multi-track rainforest symphonies.

Elements of Multimedia Databases for Browsing

In contrast to the "Mimi" software materials, the information in the Palenque prototype is for the most part structured implicitly to allow

for user-directed exploratory "experiences." One of the Palenque design goals has been to create a visually interesting database environment in which information in many formats (text, graphics, sound, narration, photographs, drawings, and motion video) can be browsed through and linked in interesting ways. We have experimented with structuring the information spatially and thematically so that children can search through realistic and visual geographical (the Palenque site) and conceptual (the Palenque Museum) spaces rather than via key words, as in the more traditional text-based database indexing systems.

In the virtual travel aspect of Explore Mode, for example, users navigate through the physical space of Palenque and discover information about the site stored in geographically appropriate locations. One must "walk" to a temple to find information about that temple. In the Museum Mode, users must navigate through the conceptual space of various theme rooms to find information related to those themes. Thus, one must visit the Maya Glyph Room in the Museum if one wants to find and explore the available information about the Pacal name glyph or the Birth event glyph. In addition, our simulated camera and album allow children to collect images of interest, make their own story of their adventures with Palenque by saving them for later reference, labeling them with a "soft" keyboard, and comparing them on side-by-side "pages" of the album.

The Palenque experience is not entirely an open-ended exploration. A few of the aspects described above provide some support in a more structured way for those who want to make use of them. These include four video overviews, which introduce the entire system as well as the individual Explore, Museum, and Game modes; the use of characters for information zooms and travel tips in the virtual travel of Explore Mode; the game-like activities in the Palenque Museum; and the Game Mode.

Elements of Interactive Books

Although Palenque resembles in some ways more traditional print materials, such as the "Mimi" student books and teacher guides, it differs in that it presents children with information in a variety of dynamic and controllable formats. The four theme rooms of the Palenque Museum, for example, can be thought of as a mix of talking book, audio-video encyclopedia, and educational movie. When children discover the howler monkeys in the Rainforest Room, they are presented with options to get information about howlers in a variety of ways. They are automatically presented with side-by-side comparative slides of howlers and text describing howlers on a screen that in some ways resembles a page in a book. In addition, by using

pictographic icons (tiny digitized images of a movie projector, an ear, and an expert's face), they can choose to see a motion video of howlers in the rainforest canopy, hear the monkeys howl, or listen to information narrated by an expert guide. With the provision of this array of information formats (slides, text, movies, sound effects, and narration), many different ways to learn about howlers are available to children.

Concurrent Process of Design and Development as Research

A traditional instructional design sequence usually involves, first, a process of needs assessment and generation of goals, then task analysis and design, production, programming and, finally, evaluation. Due largely to the experimental nature of our project, we, on the other hand, have experimented with several ongoing efforts at the same time, each informing the other. These parallel and iterative efforts have included research (formative evaluation, content research, production experiments, and technical experiments), design (treatments, scripts, and storyboards), production (filming in Mexico and studio production in the United States, as well as post-production and mastering), and programming. Although the role of evaluation in the design of most instructional videodiscs is summative, we pursued a series of ongoing formative research studies as the Palenque prototype evolved. As we proceeded through two "pink" discs, three videodisc prototypes, a CD-ROM-based prototype, and many versions of accompanying software, we observed children using them for issues of appeal, comprehensibility, and ease of interaction. We studied such things as children's understanding of virtual travel and 360° pans, their use of spatial organizers, the ease and learnability of our interface conventions, the appeal and use of our multimedia database and characters, and the effectiveness of a joystick as an input device. The results of these observational studies have led to changes in the evolving design which have been implemented in each successive disc and software prototype. In this way, we have created an ever-more appealing and comprehensible disc for our target audience.

Summary and Implications for Future Design Efforts

Many factors inherent in the Palenque project have led to a design and development process that varies in certain ways from traditional instructional design projects. Interactive videodisc courses are often designed to train adults in corporate settings. They are typically based on the principles of task analysis, are often intended to teach sequential procedures, and strive for learning efficiency as well as efficacy. The design process usually involves summative evaluation.

Palenque, by contrast, was designed for use in homes to entertain and inform families with children in the 8- to 14-year age range. With this intended setting and audience in mind, it has its roots more firmly based in discovery-learning theories as it provides family users with a rich multimedia information space to explore in a self-directed and "real-world" way. Extended sessions with the disc and repeat visits are encouraged by the open-ended nature of the Palenque experience. Largely because the Palenque prototype has been designed for the David Sarnoff Research Center's evolving DVI technology, our development process has been an ongoing, iterative process of design, implementation, and formative research with children.

The many design experiments involved in the Palenque project have led to several insights that we plan to incorporate into future optical disc design and development projects. First, we think that more efforts need to be made to develop new ways to organize, access, and link visual and auditory information in optical disc-based databases and simulations for use by children. Connections between pieces of information (especially non-text-based) may be made in a number of ways other than via key-word searching and sorting through massive amounts of text. As we have seen in the Palenque prototype, highly visual menus that allow users to connect information spatially and thematically are a step in this direction. They may even encourage certain forms of incidental learning. Also, narrative elements such as a central theme and location and the consistent use of characters seem to offer a type of implicit structure to the database information that supports and motivates young users.

In addition, allusions to real-life experiences, such as taking trips to ancient sites or visiting museums, may be powerful vehicles for structuring information in rich, multimedia, optical disc-based environments for children. We plan to study children's understanding of a variety of nontraditional learning contexts and experiences, which may form the basis for metaphors of database and interface design in the future. For example, the motivation and structure inherent in the design of a good museum exhibit or summer camp may be analyzed and modeled for the automatic appeal and comprehensibility children find in them. By incorporating these metaphors into the design of optical disc-based applications, the environment and the interface seem to merge into the same thing, making them more accessible, informative, and motivating for children.

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